

## ***Interactive comment on “Investigating the relationship between volume transport and sea surface height in a numerical ocean model” by Estee Vermeulen et al.***

### **Anonymous Referee #2**

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This manuscript uses a numerical model of the western Indian Ocean, Agulhas Current region, to investigate the performance of the Beal and Elipot (2016) transport proxies that were developed using in situ mooring observations and satellite altimetry. While the intention of the study is sound, the study does not actually use the numerical model to full advantage. The investigation of the robustness of the proxy is limited and the study does not fully explore the dynamical reason why the proxy fails in some instances (“box”) and almost entirely for the “jet”. If the study was more thorough in identifying the dynamical reasons for failure of the proxy this study could be used as a basis for either suggesting and exploring a more appropriate region where a simple proxy as proposed may be of value or identify dynamical instances where the proxy is accurate.

Thus this study is potentially interesting, but fails to make use of the numerical model to fully explore the validity or not and why of the proposed Agulhas current proxy.

In addition to a more detailed dynamical exploration, the manuscript would benefit with a reorder and editing. For example, in the Summary and Conclusion section the authors state (line 534-537) “The HYCOM model provided the means to investigate the validity of the assumptions used to create the proxies, such as the constant relationship between SSH slope and transport per unit distance at each mooring location and the temporal scale of observations needed to build a strong linear relationship between transport and SSH slope.” They then follow with a limited discussion explaining some reasons why the proxy does not capture the model transport, referring to figures to justify this reasoning – this is not a summary or conclusion. It is suggested that much of the information (lines 534-628) should be incorporated into the relevant parts of Section 3.

A reordering of Lines 629-696 would form what may be considered a “Summary and Conclusion” sections.

Section 2.1 should only provide details of the model used in this study. The reader is not interested in the details of the larger regional model that provided the boundary conditions of the higher resolution (1/10o) nested model.

The presentation of section 2 was convoluted and thus difficult for the reader to easily understand the approach taken. It is suggested that the authors revise this section to more clearly and concisely explaining the methods and assumptions.

Lines 275-290 “The length scales of the slopes ranged from 24 km at mooring A to 12 km at mooring G and 48 km for the offshore CPIES-pairs, indicating an increase in the spatial scale of offshore flow, possibly due to increased offshore variability. Results from the in situ proxy experiment by Beal and Elipot [2016] also showed an increasing length scale with increasing distance offshore, however the results varied considerably in magnitude: 27 km at mooring B to 102 km at mooring G.” Can you explain the

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reason for the difference in length scales between the model and observations (in situ and satellite)? Does this indicate the model doesn't capture the observed variability? What implications does this have for this study?

It is suggested that section 2.4.1 be revised to remove any unnecessary information concerning the larger regional model.

Line 407-408. "The proxies only capture a portion of the transport estimate from the HYCOM model, suggesting it also only captures a portion of the model variability." Is this the only problem with the proxy estimate? A more detailed analysis is really required to understand the impact of the assumptions used in developing the proxy.

Line 418-420 "In summary, the results indicate that the proxy is generally better suited in HYCOM to estimate the box transport rather than the jet transport. Further analysis in this study therefore only focuses on the box transport." It is not appropriate to simply ignore results that don't agree. You need to fully explore the reasons why the different proxies fail.

Lines 485-499 Removing outlier to increase the performance of the proxy is not appropriate. The authors should clearly identify the dynamical reasons for the reduced skill of the proxy. It is only through this in-depth analysis that advantages and disadvantages of the proxy can be fully explored.

The manuscript is lengthy and the prose overly convoluted and repetitive, when reviewing the manuscript the authors should, where possible, simplify the writing and remove repetition. Below are a few examples:

Line 85-89 "The Agulhas transport proxy of Beal and Elipot [2016] was derived from the physical principle of geostrophy, where along-track sea surface height slope measured by satellite altimeters can ultimately be related to a measure of volume transport across a portion of the current, provided that the surface current represents the flow at depth [Beal and Elipot, 2016]. " can be deleted as lines 89-93 fully explain the major findings

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of the Beal and Elipot, 2016 study.

Line 151 change "... in doing so..." to ".. thus ..."

Line159-161 remove "The horizontal resolution of the parent model ranged from 14 km in the northern Indian Ocean to 45 km in the Southern Ocean, with a resolution ranging from 30 to 40 km in the region of the Agulhas Current." This information is not needed; the reader can refer to George et al., 2010 if they require more information on the model from which the boundary conditions were taken.

Line 154-155 Change "The HYCOM output in this study was made available from a nested 1/10° model of the greater Agulhas Current System (AGULHAS) [Backeberg et al., 2008; 2009; 2014]." To "This study used output from a nested 1/10° model of the greater Agulhas Current System (AGULHAS) [Backeberg et al., 2008; 2009; 2014]."

These are a few examples; there are many more instances of repetition and where more concise writing would improve the text.

#### Minor comments

Line 45 change "As the current continues southwestward the current becomes.." to "As the current continues southwestward it becomes.. "

Line 60-62 poorly constructed sentence "The unique circulation of the Agulhas Current System, in the context of regional and global climates, makes it an important field of research."

Line 67: "However, the close proximity of the current to the coast makes it difficult to monitor using satellite altimetry [Rouault et al., 2010]." Is this statement still true given the development of the AVISO X-track product (<https://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products/regional/x-track-sla/coastal-along-track-sea-level-anomalies.html>)?

Line 74-84. It can be shown that the total cost of in situ observing, satellite observations

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and models are all on similar cost. Singling out in situ observations as the only costly tool is not appropriate or accurate.

Change “ In situ observations may accurately measure the dynamics of the Agulhas Current throughout the water column but are expensive and spatially coarse.” To “In situ mooring observations provide high temporal observations of the Agulhas Current throughout the water column but spatially coarse.”

Line 106 Change [Beal and Elipot, 2016] to Beal and Elipot [2016]

Line 120 Change Zhu et al. [2004] to [Zhu et al., 2004]

Line 158-159 Change “.. buffer zone.” To “.. sponge layer.”

Line 166-167 Change “Both models have 30 hybrid layers and targeted densities ranging from 23.6 to 27.6 kg/m<sup>3</sup>. To “AGULHAS has 30 hybrid layers and targeted densities ranging from 23.6 to 27.6 kg/m<sup>3</sup>.”

Line 185 Add “ . . . 2010-2013 (Figure 1, Beal et al., 2015).

Line 193-195 Change “During the first phase of the ACT experiment, the mooring array was maintained in the Agulhas Current for a period of 34 months, perpendicular to the continental slope at 34°S, south of East London, South Africa (Figure 1).” To “ The ACT mooring array was located perpendicular to the continental slope at 34°S, south of East London, South Africa (Figure 1).”

Line 200 Change “ From the data collected in Beal et al. [2015], two volume transports were estimated: . . . “ to “From the data collected, Beal et al. [2015], provided two volume transports estimates: ..”

Line 202 Change “. . . is a net transport” to “. . . is the net transport ..”

Line 218 Remove “Based on physical principles sea surface slope is proportional to surface geostrophic velocity.”

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## Line 237 Define Tx and Txsw

Line 269 “The coordinates of the along-track altimeter data were obtained from the filtered 12km Jason-2 Aviso satellite product, and not the unfiltered 6 km product which was used for the original ACT proxy [Beal and Elipot, 2016], since the 12 km product matched the  $\sim 10$  km model resolution more closely.” Is this difference significant given that the model is interpolated onto the altimetry ground track?

Figure 2 Caption. Change “Figure 2: HYCOM transport per unit distance proxy ( $m^2 s^{-1}$ ) for Tx (blue) and Txsw (red) transport at 1 km intervals at the first model time step (solid lines, week of 3rd January 1980) and for the mean reference period (dashed lines). The faint grey lines represent the positions of moorings and offshore CPIES pairs.” To Figure 2: HYCOM transport per unit distance proxy ( $m^2 s^{-1}$ ) for Tx (blue) and Txsw (red) transport at 1 km intervals at the first model time step (solid lines) and for the ACT reference period (2010-2013, dashed lines). The grey dashed-lines represent the positions of moorings and offshore CPIES pairs.”

Line 303-306 remove “Tx and Txsw are simply shown at the first model time step (week of the 3rd of January 1980) in HYCOM and for the mean of the reference period (2010-2013) to show the difference between the net and southwest transport components used to calculate Tbox and Tjet (Figure 2).”

Line 411 Remove “Figure 4 shows the correlation between proxy and model transports for each year.”

Line 413 Add “. . .insignificant minimum correlation of 0.00 (2003) (Figure 4).”

Line 413 Change “. . . correlation of 0.82 (2014) and an insignificant minimum correlation of 0.00 (2003).” To “. . . correlation of 0.82 (2014) and a minimum correlation of 0.00 (2003).”

Lines 428-431 Remove. “Figure 5 shows the surface variability by displaying the eddy kinetic energy and the mean surface geostrophic flow as represented by the overlaying

SSH contours over the 3-year reference period, and over the highest (1988) and lowest (1994) correlated years of the box transport proxy.”

Any important information in this sentence should be included in the figure caption.

Line 431-432. Add “During the reference period the current appears to be stable with low levels of EKE inshore whereas offshore the flow is more variable with higher levels of EKE (Figure 5).”

Line 445 Remove “Figure 6 shows the mean cross-track velocity profiles during the reference period (2010- 2013), the highest correlated year (1988) and the lowest correlated year (1994) for each mooring and the CPIES-pairs.”

Any important information in this sentence should be included in the figure caption.

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